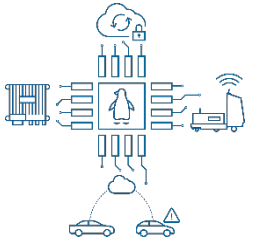
OPEN SESAME!

WHY FUNCTIONAL SAFETY IS THE MASTER KEY TO OPEN THE DOOR FOR LINUX INTO AUTOMOTIVE SYSTEMS

Authors: Nico Peper, Jan-Christian Arnold, Hans-Leo Ross

Agenda



1. Why Automotive Software is special
2. Short introduction to Automotive Safety
3. Introducing an example: Linux powering Vehicle to Infrastructure communication (V2X)
4. Implementing ASIL B on a V2X traffic light
5. Safety relevant open questions in a V2X context
6. Conclusion

WHY AUTOMOTIVE SOFTWARE IS SPECIAL & SHORT INTRODUCTION TO AUTOMOTIVE SAFETY

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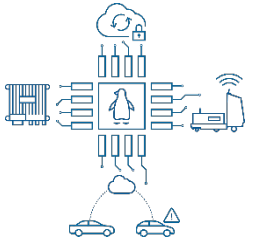
Why Automotive Software is special



Open source

- Most automotive systems are powered purely by closed source software
- Licence obligations, like given in GPL V3, are often a blocking point

LTS

- Automotive base requirement is a 15 year product live cycle

Process

- To achieve high volume low cost scalability process orientation is the automotive fundamental approach

Legislative

- Safety -> Functional safety -> ISO26262

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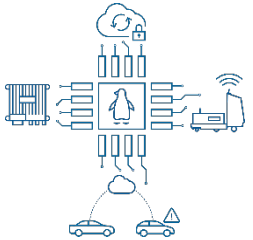
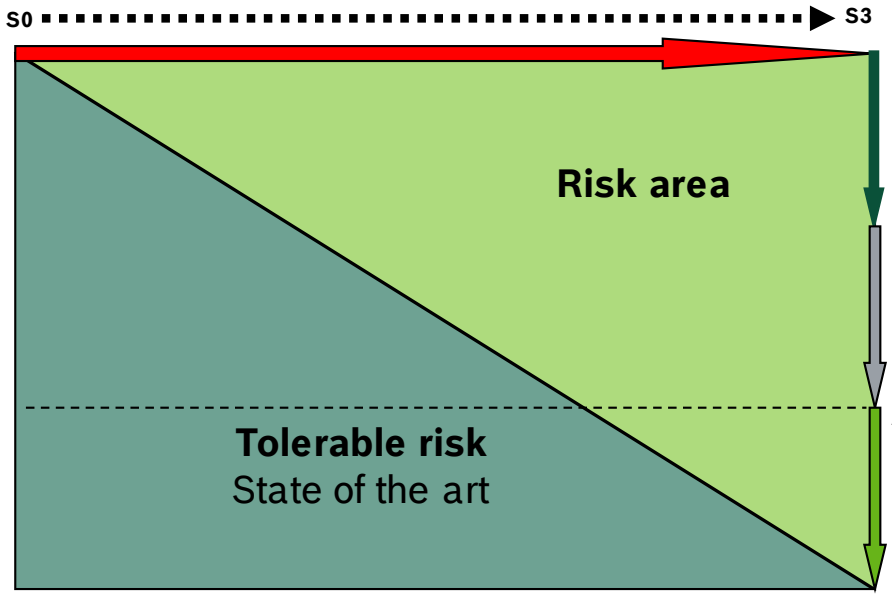
Short introduction to automotive safety



Potential damage caused by the operation of the vehicle or additional functions (S = extent of damage)



E4

Probability of hazardous situation
- **E = probability.**
  (Situation x risk)

E1
C3

Aversion of dangerous events
- **C =Controllability**
- Measures of other technology
- External measures
- Driver warning, if regulated by law

C0
ASIL A

Safety Integrity Measures according ISO 26262

only risk due malfunctions of EE system considered!

ASIL D

Area of risk and tolerable risk (Source: various different publications)

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INTRODUCING AN EXAMPLE: LINUX POWERING VEHICLE TO INFRASTRUCTURE COMMUNICATION (V2X)

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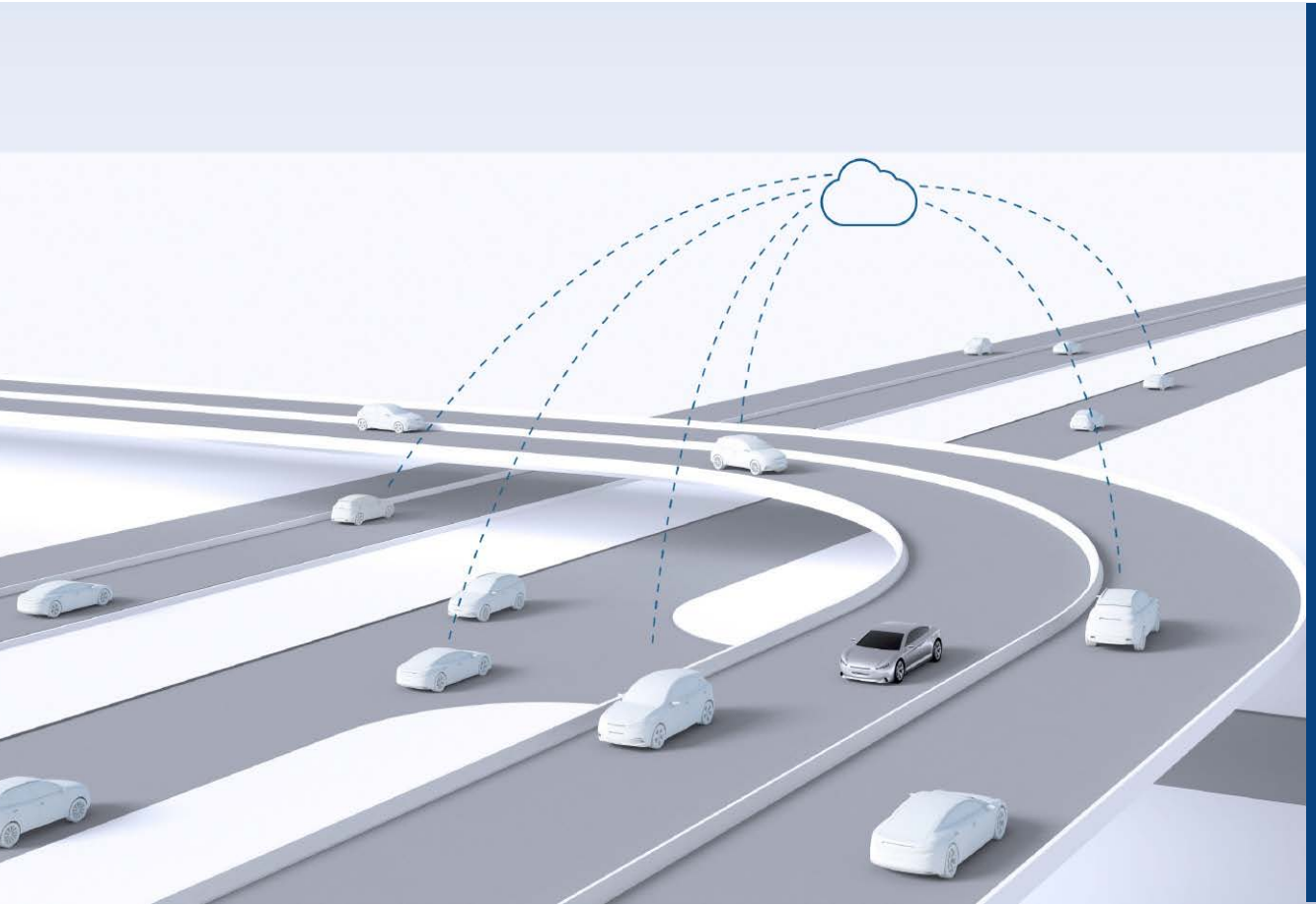
Linux powering V2X communication



- V2X enables the direct communication between cars (V2V) and infrastructure (V2X)
- It's an enabler for advanced driving assistance and autonomous driving functions
- US government is actively pushing V2X systems by legislation. Standard will be released soon
- Todays V2X communication stacks are POSIX based implementations
- Systems need to handle complex and non-deterministic systems and algorithms (Fuzzy, neuronal networks etc.)

→ Linux will make a clear push to autonomous driving systems by operating V2X

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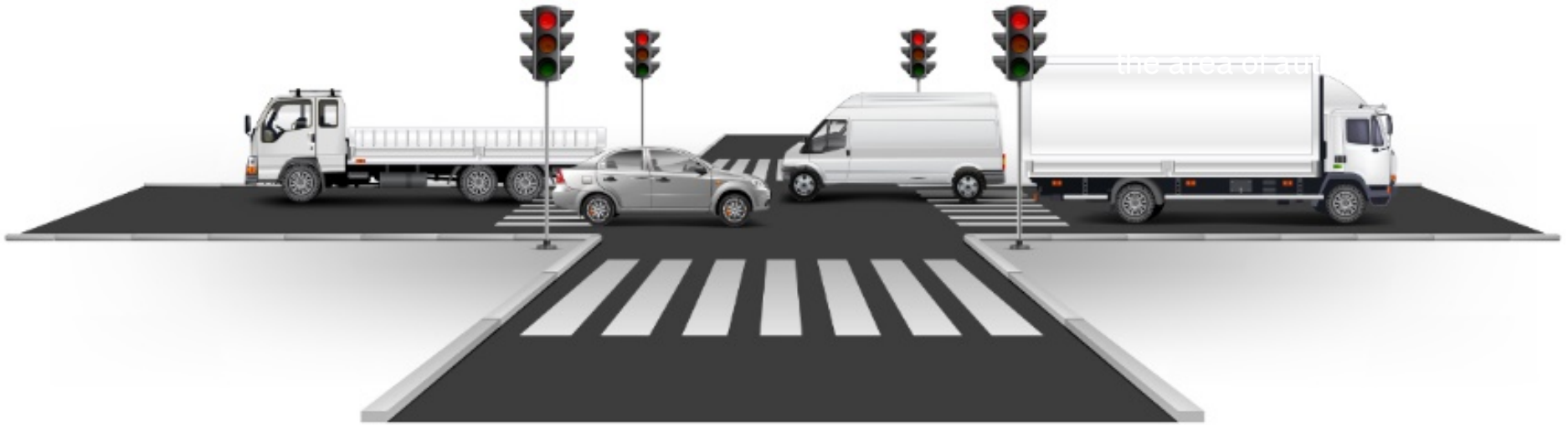
Linux powering V2X communication



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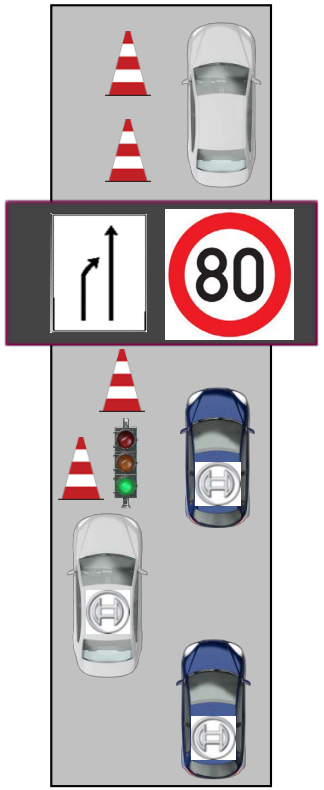
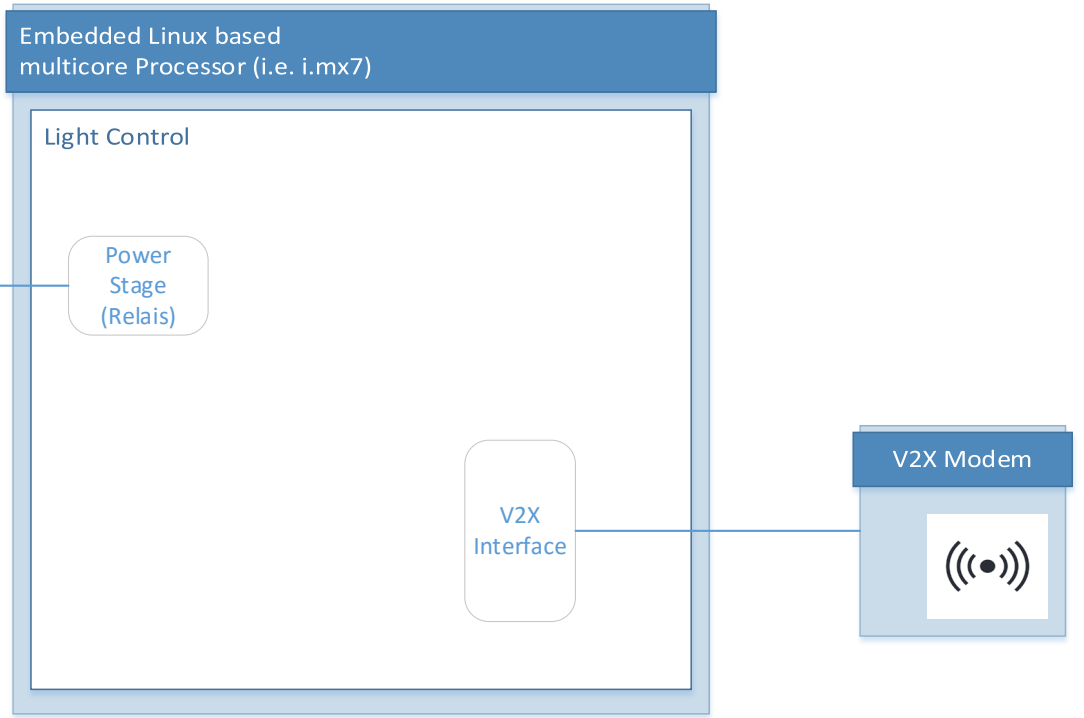
Linux powering V2Xcommunication



System level



Base layout for connected traffic light control system

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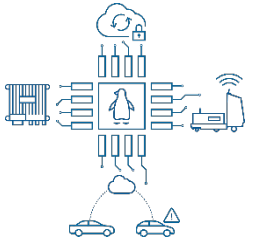
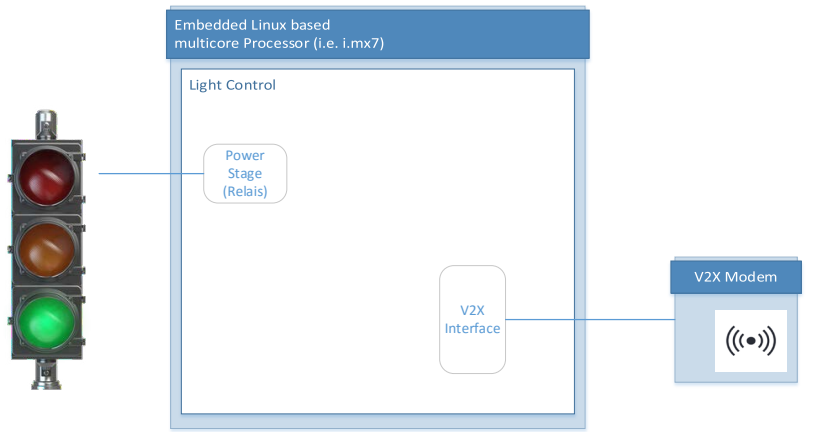
Linux powering V2X communication





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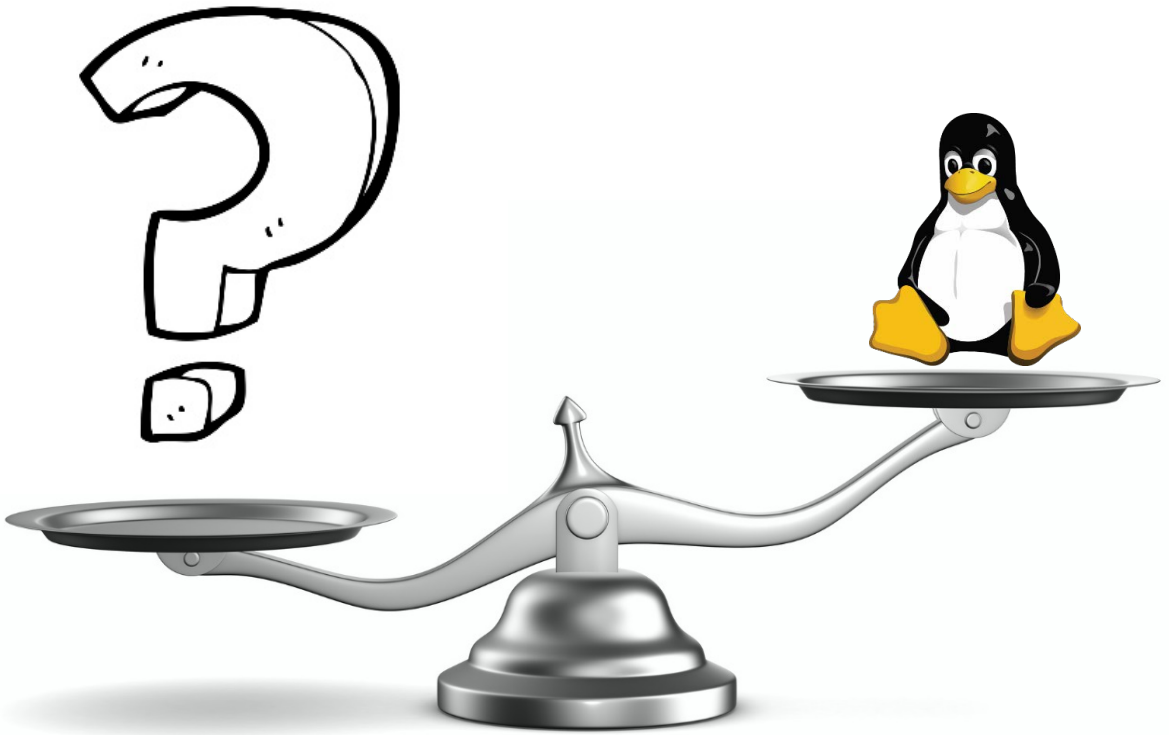

IMPLEMENTING ASIL B ON A V2X TRAFFIC LIGHT

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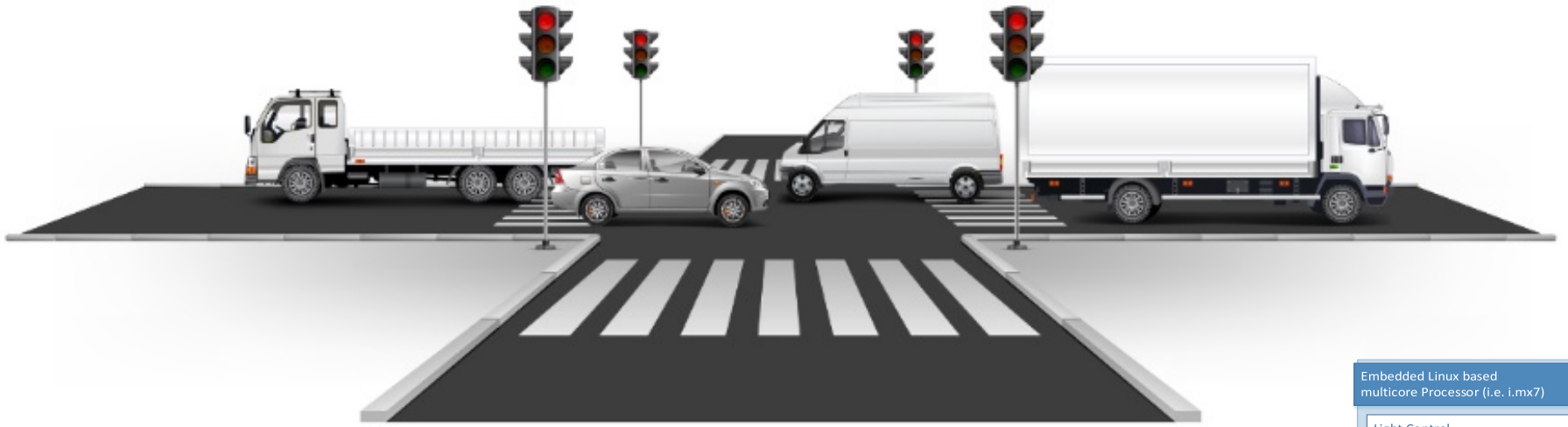
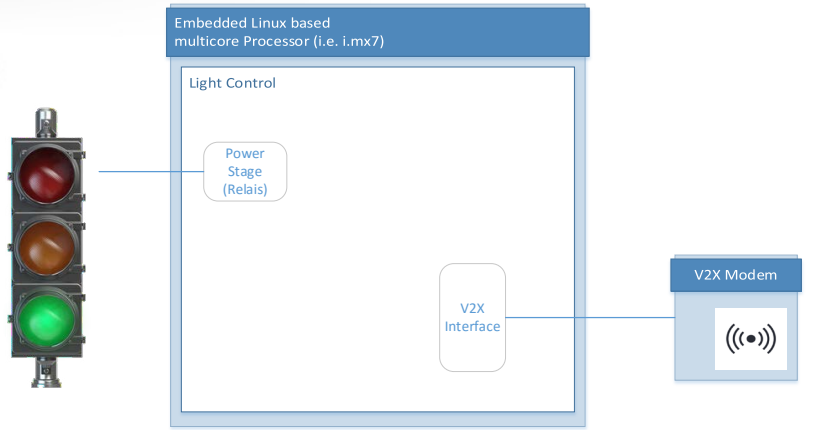
Implementing ASIL B on a V2X traffic light





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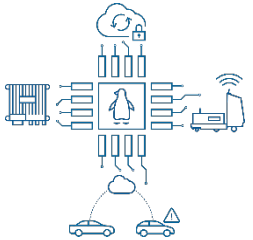
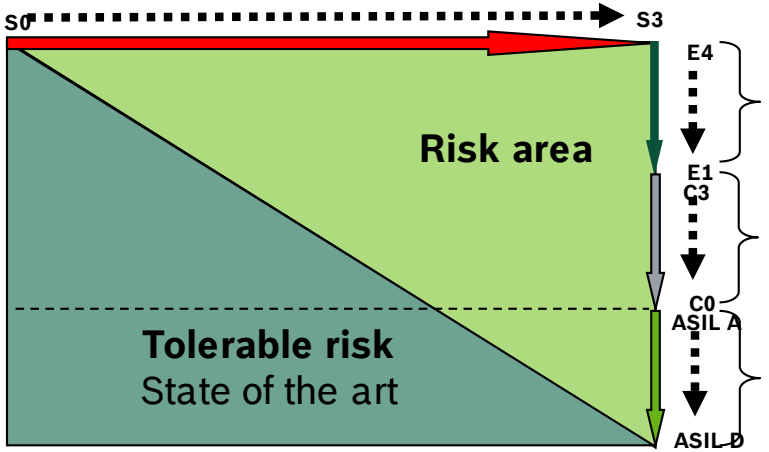
Implementing ASIL B on a V2X traffic light



- In contrast trying to reach ASIL B by handling the system based on processes a system within system functionality view within given context needs to be introduced
- Hazard risks are safely to be reduced by determine their severity (expected loss) and frequency / probability
- The system functionality must be reliable and in case of system errors a sufficient safety level (safe state) needs to be achieved
- State of the art safety measures are needed to assure safe operation of vehicles!



$$R = \sum_{\text{For all accidents}} (\text{probability of the accident occurring}) \times (\text{expected loss in case of the accident})$$

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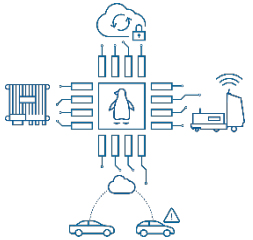
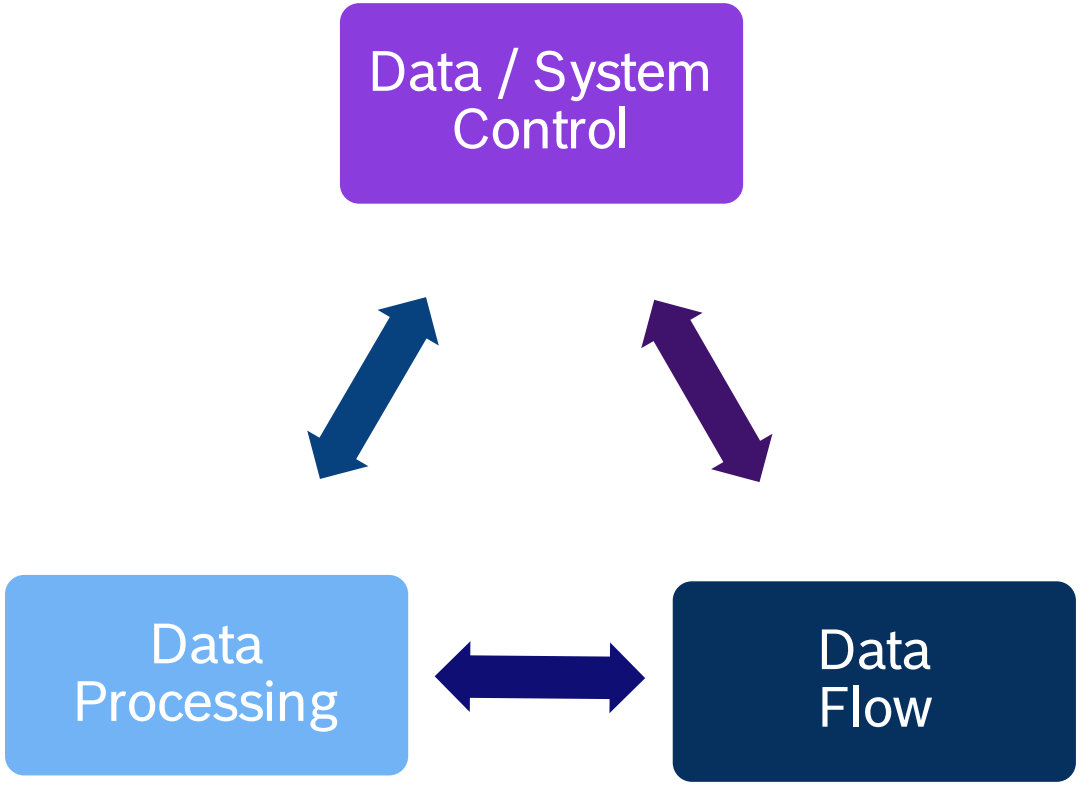
Implementing ASIL B on a V2X traffic light



- An IT system may be represented by it's basic functionalities:
  - Data and system control
  - Data flow
  - Data processing

- To achieve safety integrity of the overall system these basic functionalities need to be monitored and validated



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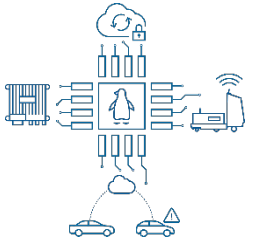
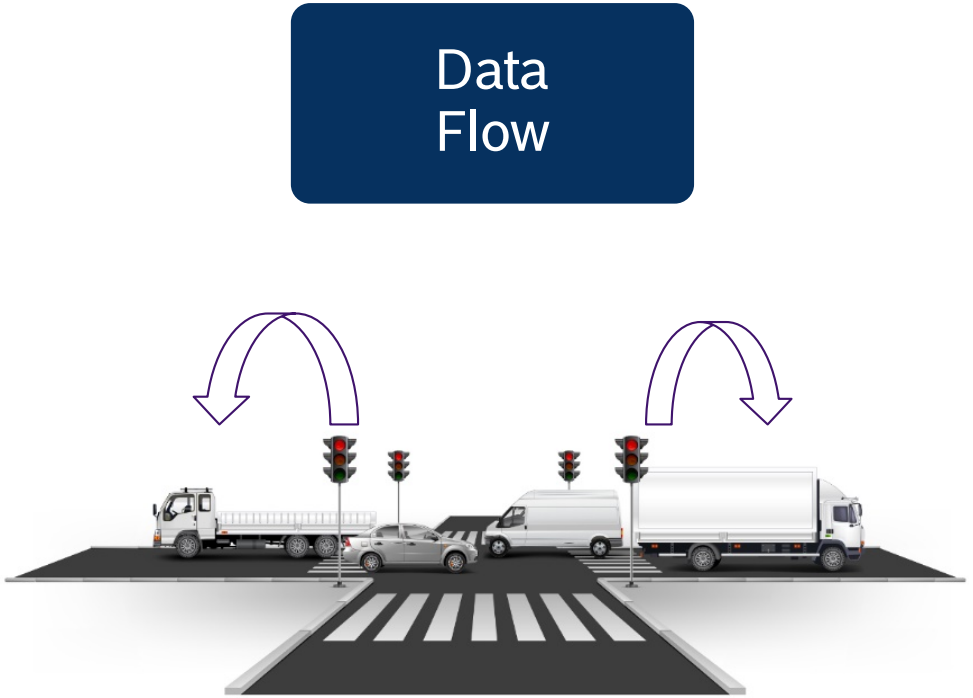
Implementing ASIL B on an V2X traffic light





- Example
  - Data exchange between car and traffic light via radio (i.e. dedicated short range communication)
- Safety target:
  - Ensure data flow integrity
  - Ensure safe modes & conditions in driving situations
- Monitoring mechanisms
  - Checksum & message Counters
  - Cyclic Redundancy Checks
  - Keyed-Hash Message Authentication Code

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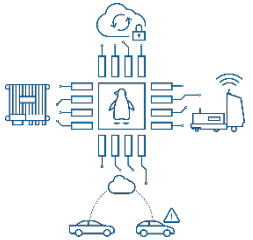
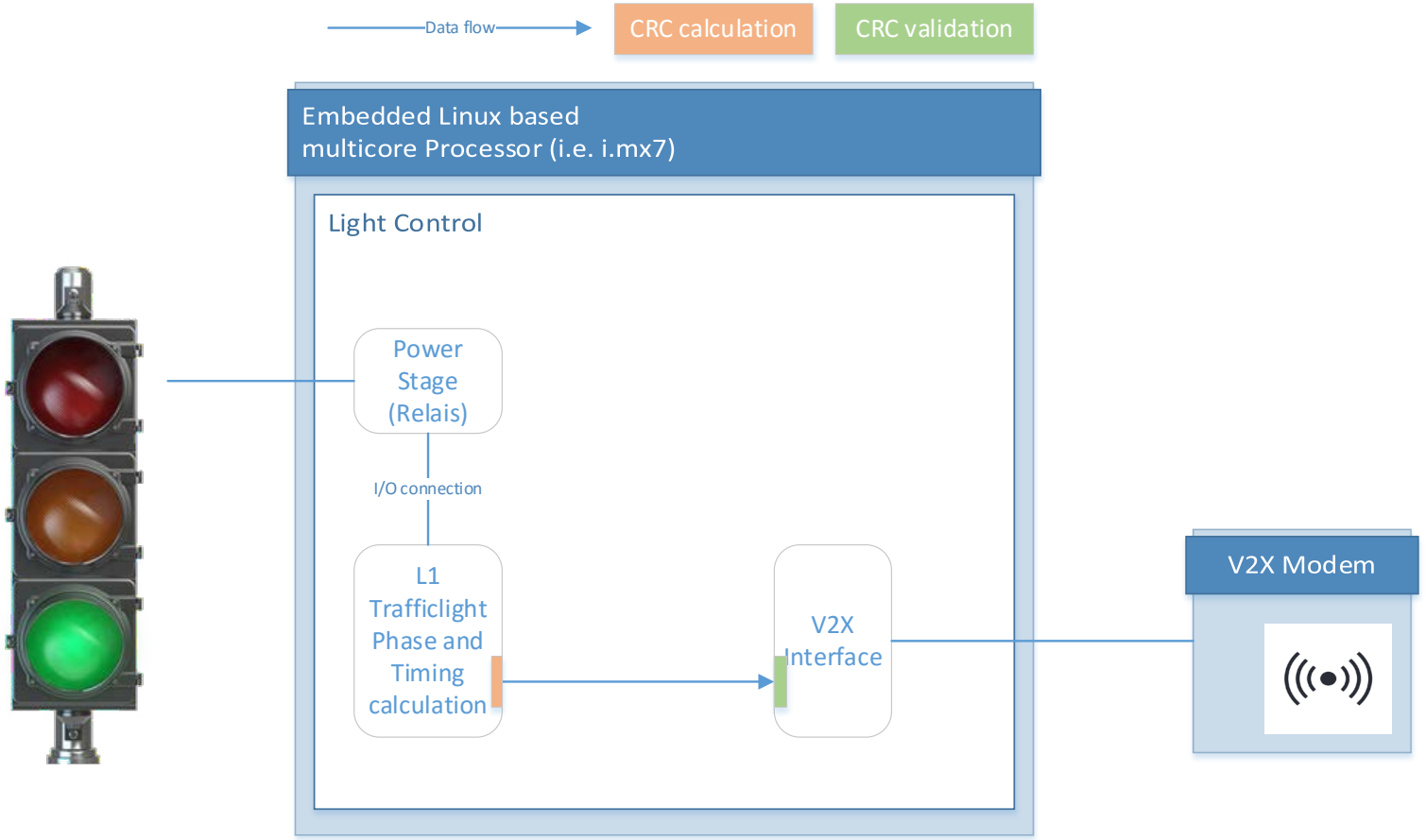
Implementing ASIL B on an V2X traffic light



Data Flow



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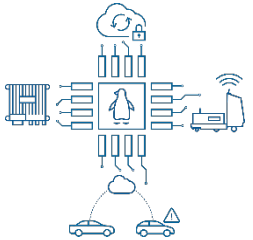
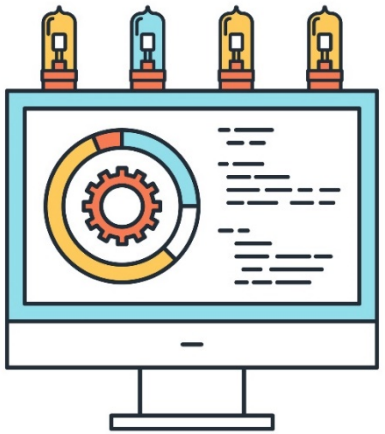


Data Processing



- Example
  - Process traffic light status for the V2X communication stream
- Safety target:
  - Ensure data integrity by avoiding calculation based errors, i.e.:
    - bit errors
    - rounding or overflow errors
- Monitoring of data processing
  - Redundant calculation including diverse calculation based on different data structures / types etc.

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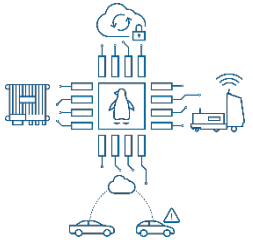
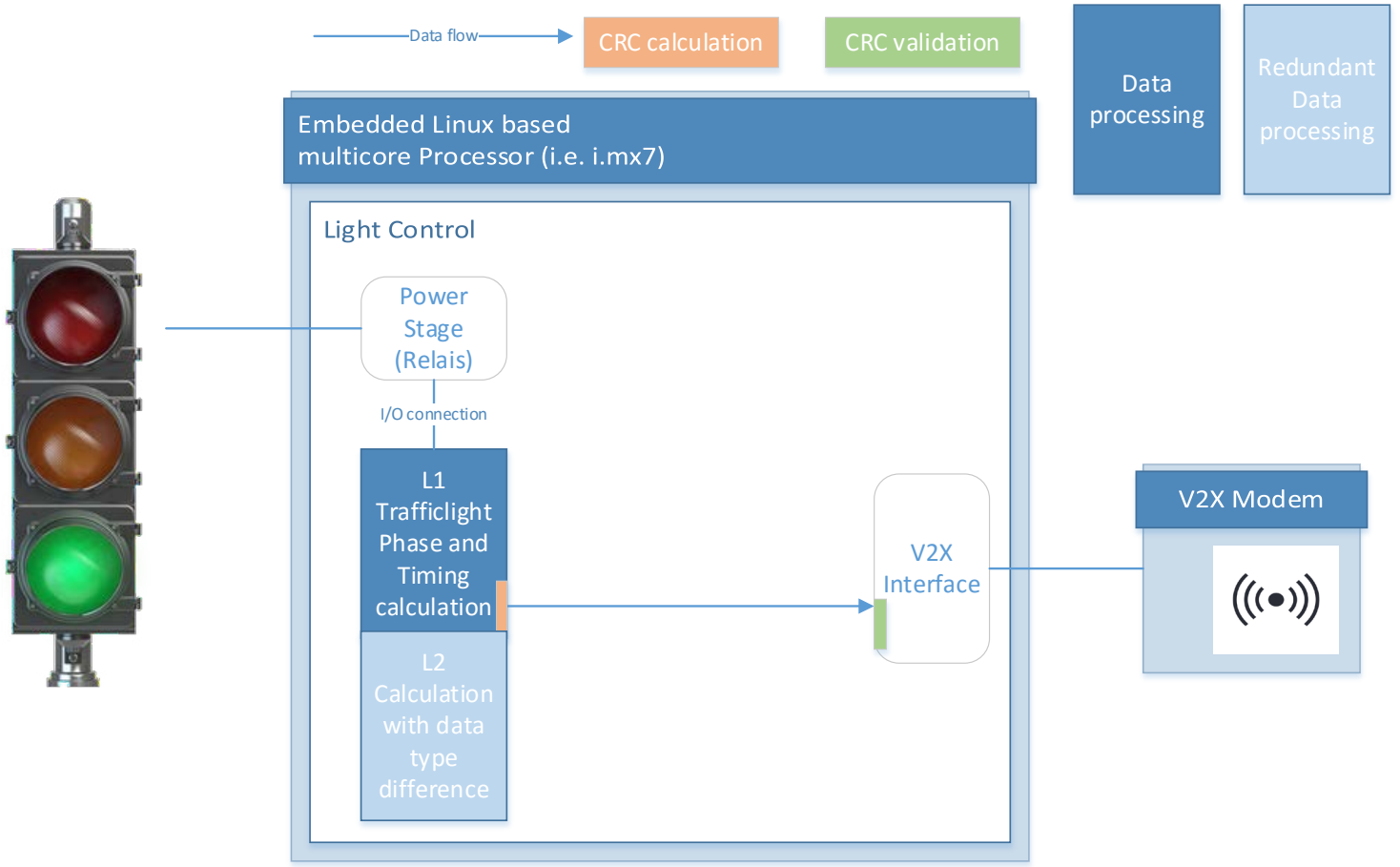
Implementing ASIL B on an V2X traffic light





Data Processing

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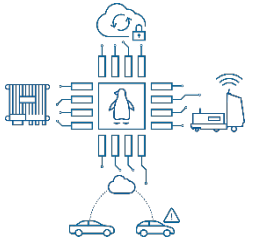
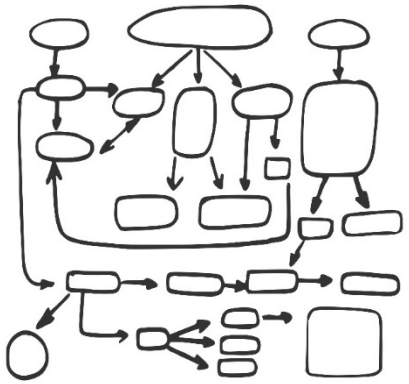


Data / System Control



- Example
  - Operating traffic light colours and status (i.e. system control state machine)
- Safety target
  - System control integrity is ensured
- Monitoring
  - Monitoring of forbidden states

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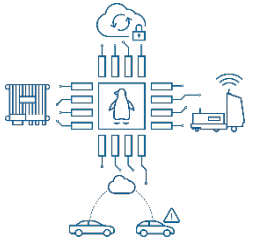
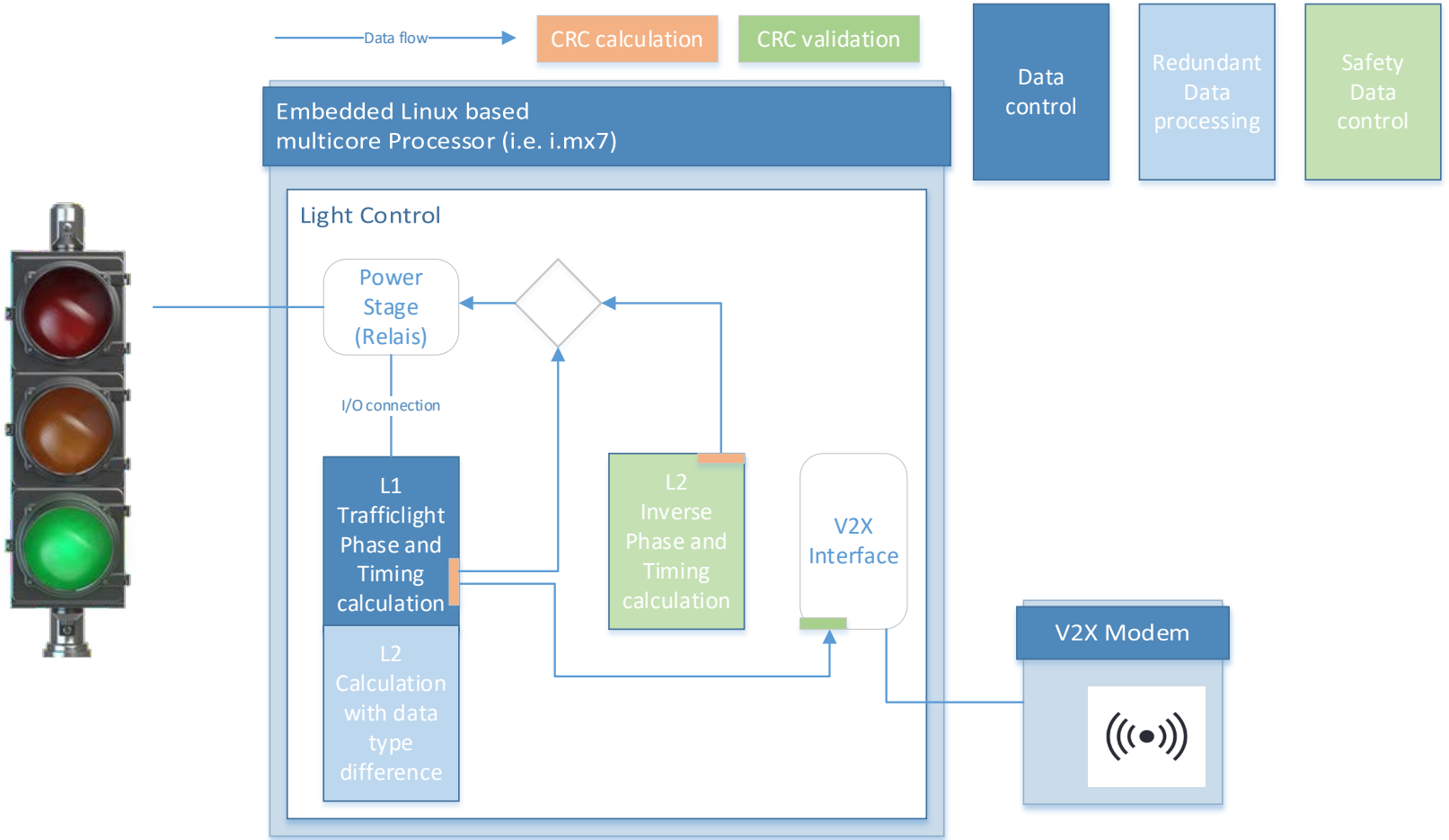
Implementing ASIL B on an V2X traffic light





Data / System Control

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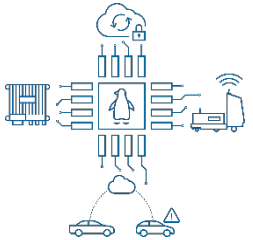
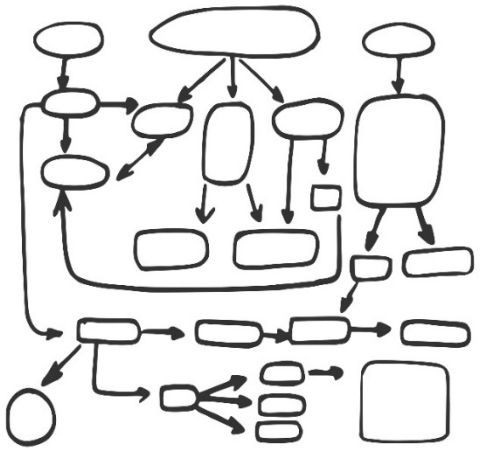


System Control (real time integrity)



- Example
  - Ensure correct real time behaviour of the traffic light
- Safety target
  - Traffic lights are operated conforming the real system state
- Monitoring
  - A safely operated entity is needed to ensure the system operation and the traffic light feedback (deadline monitoring)

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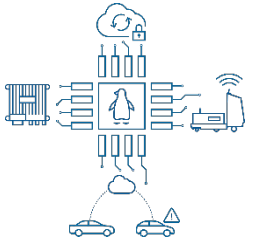
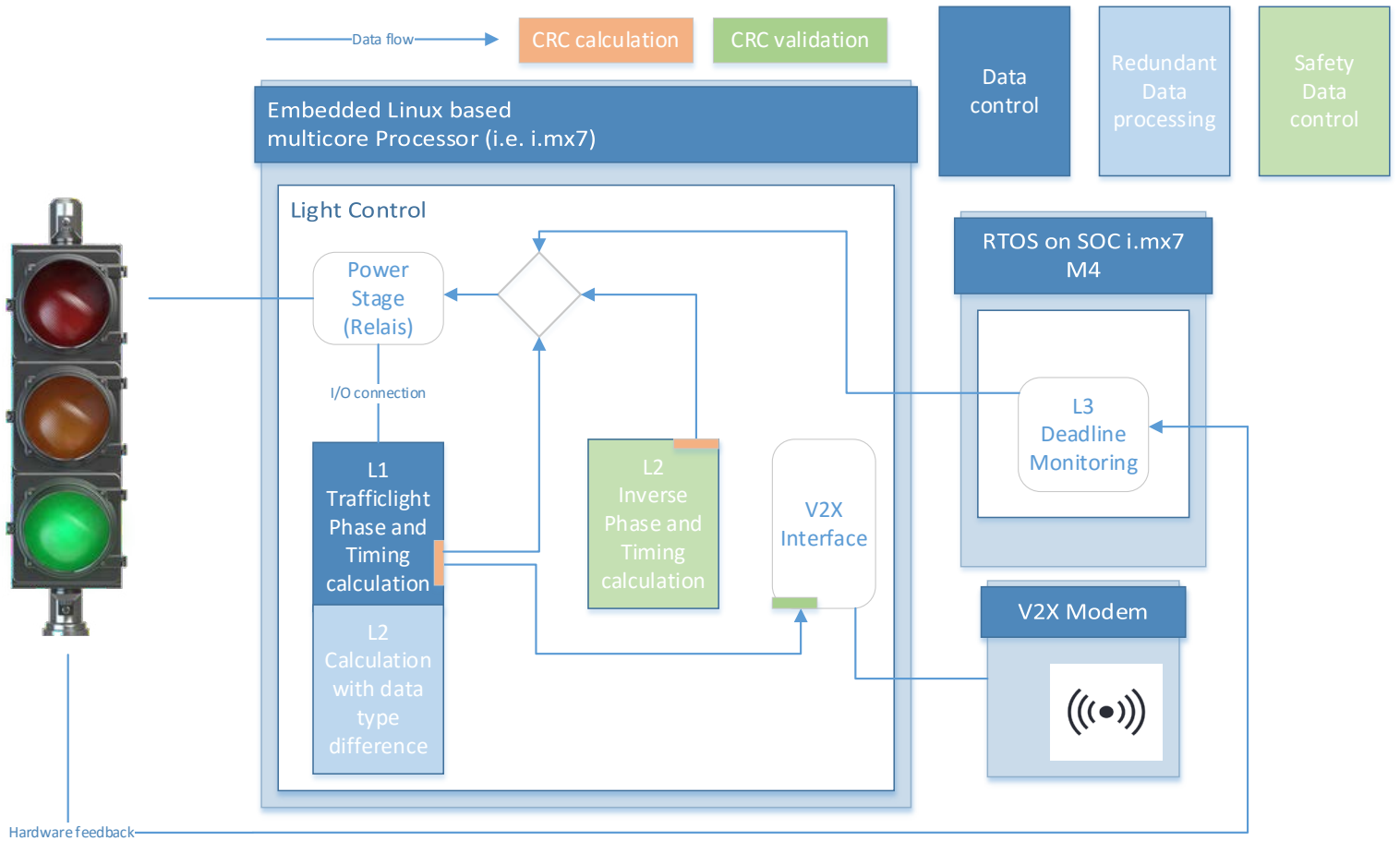
Implementing ASIL B on an V2X traffic light





System Control (real time integrity)

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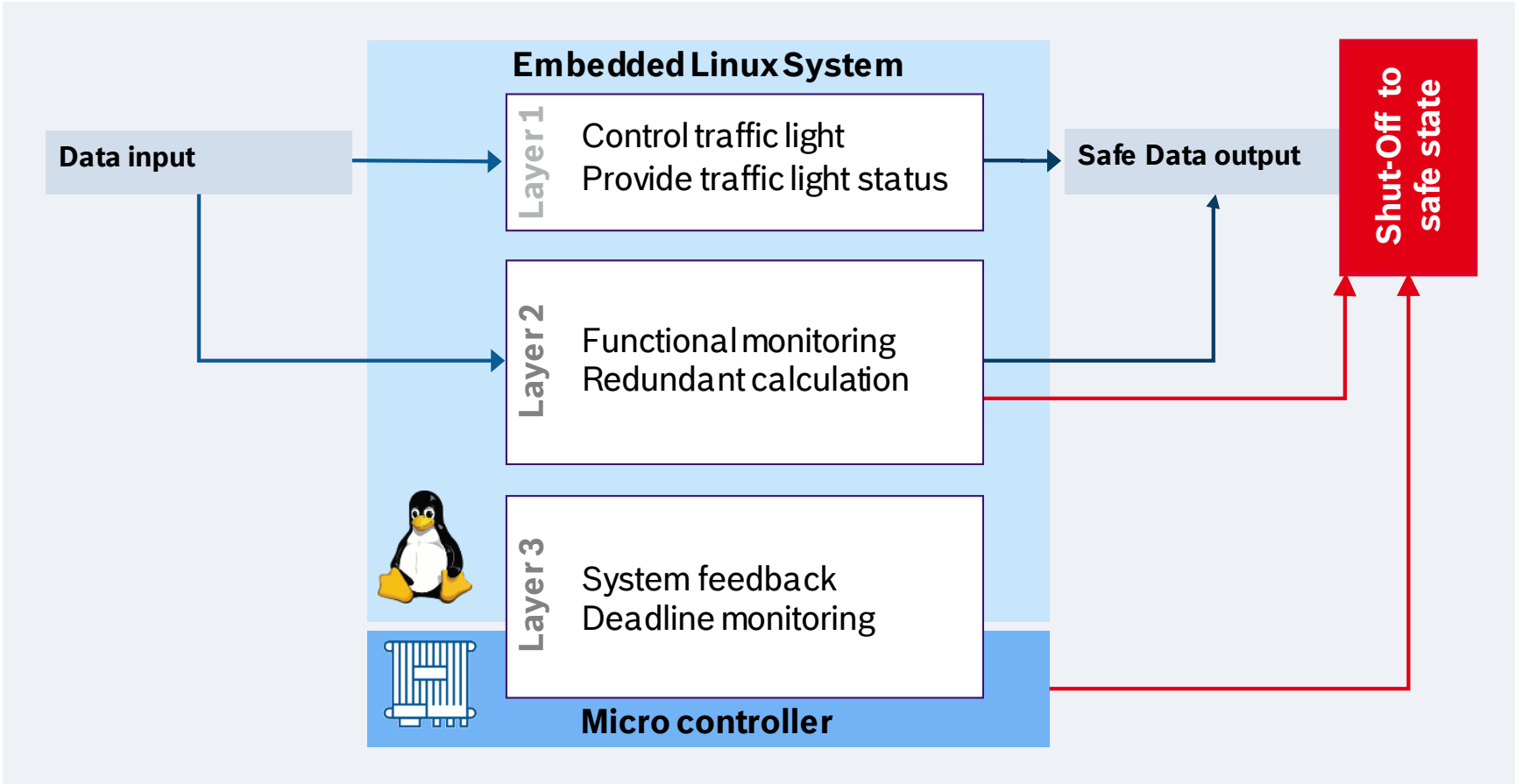

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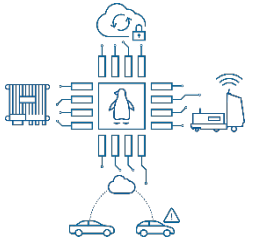
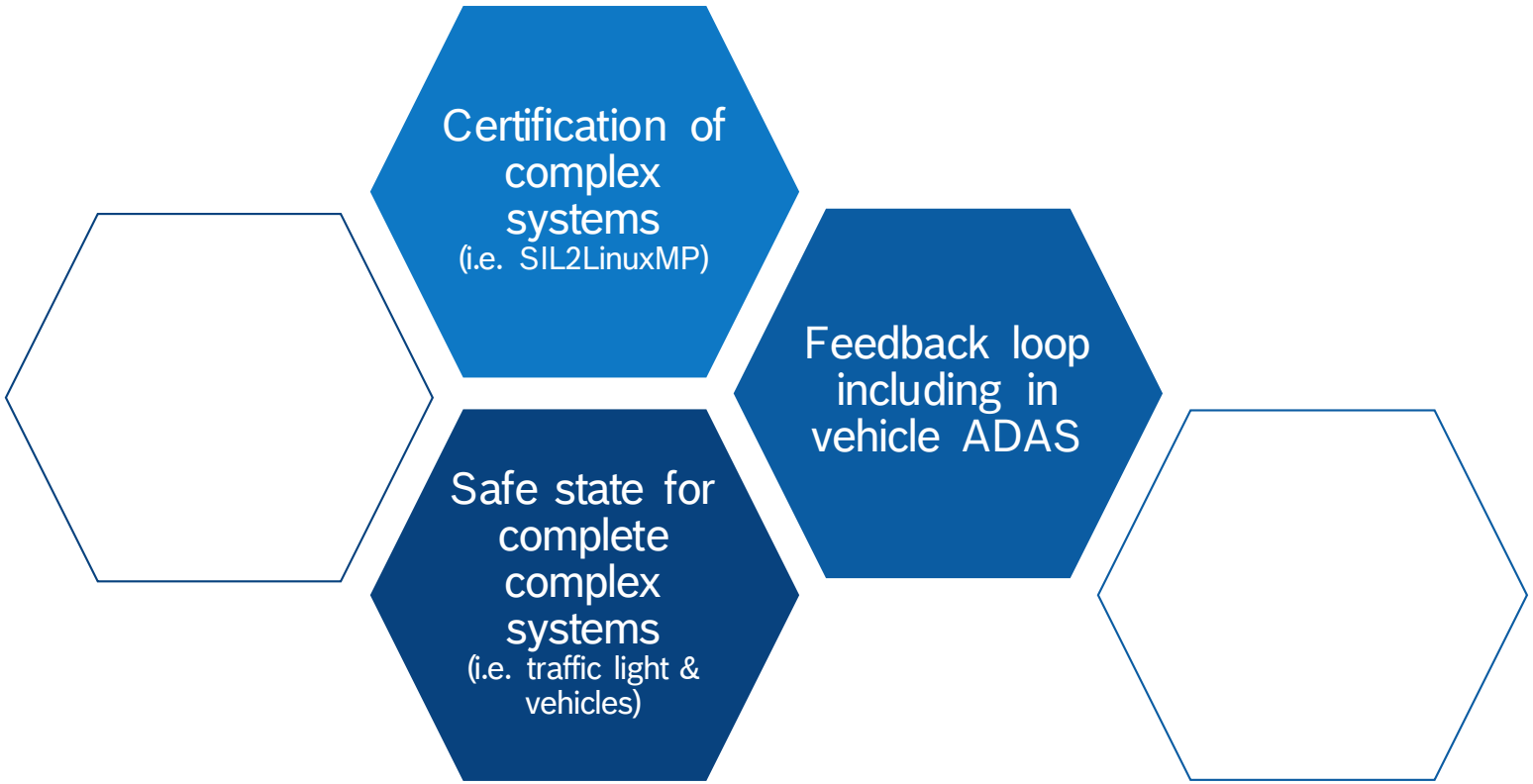
Safety Relevant Open Questions in a V2X Context





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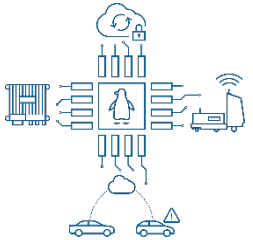
Conclusion



- Embedded Linux is making a clear push to automotive core systems

- Presented challenges concerning embedded Linux (i.e. licence obligations, real time behaviour and ASIL conformity) can be tackled

- By introducing the functional view to system safety Linux isn't a blocking point for functional safety

- The three layered safety concept is proven in use in various product families and can be fully applied to embedded Linux systems

- Challenges exist! They still need to be solved
  - This should be a shared effort of the automotive industry and the Linux community

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